DEPOSITS OF VERMICULITE AND OTHER MINERALS IN THE RAINY CREEK DISTRICT, NEAR LIBBY, MONT.

By J. T. Pardee and E. S. Larsen

SUMMARY

The deposits described are in an easily accessible area about 7 miles northeast of Libby, Mont. They occur in a stock of alkaline rocks that is intrusive into argillite and quartzite of the Algonkian Belt series. About two-thirds of the stock consists of a coarse-grained pyroxenite that ranges from nearly unmixed pyroxene to nearly unmixed biotite or its alteration product vermiculite and generally contains an unusual amount (7 to 10 per cent) of fluorine-rich apatite. In addition, the analysis of a representative sample shows the presence of more vanadium (0.12 per cent V_2O_3) than occurs in igneous rocks generally.

The remainder of the stock is coarse-grained syenite composed chiefly of intergrown potash and soda feldspars (microcline microperthite) and altered nepheline syenite composed chiefly of microperthite and nests of secondary muscovite. Near the main igneous body is a dike of fresh nepheline syenite.

Widespread and unusual changes in the stock have been caused by hydrothermal action. The principal minerals thus produced are white mica, aegirite and aegirite-diopside (both locally vanadiferous), vermiculite, and fibrous amphiboles. Locally titanite and feldspars are developed and also veins containing a variety of minerals.

A large body of the vermiculite is being developed commercially by the Zonolite Co. In addition several smaller bodies are being explored by the Vermiculite & Asbestos Co., and in some of these bodies the mineral makes up from 30 to 84 per cent of the pyroxenite country rock. Vermiculite is comparatively new to commerce. It is a micalike mineral containing a large amount of water. Upon being heated it expands enormously and assumes golden or silvery lusters. The expanded material is so light that it floats on water. It appears to have a low heat conductivity and to resist high temperature. The Zonolite Co. reports 1,500,000 pounds mined and sold under the trade name "Zonolite." The uses of zonolite include fireproof roofing, wall board, and similar material, packing for refrigerators, sound-deadening plasters, boiler covering, electrical insulation, and wall-paper decoration.

On the spur north of Kearney Creek much of the pyroxene of the large pyroxenite body has been altered to amphibole of a fibrous habit that is known commercially as amphibole asbestos. Bodies of a dikelike form 14 feet or less in width consist of nearly unmixed amphibole asbestos (near tremolite), and in several places this substance composes from 50 to 75 per cent of the country rock. A small amount has been mined for experimental purposes, but no commercial production is reported. The material near the surface is rather easily

separated or fiberized. The fibers are weak and inelastic, but they compose a fluffy mass that to all appearances is similar to the ordinary run of amphibole mass fiber.

The syenite body contains large masses of nearly unmixed alkaline feldspar, but whether its quality is such as is required in the ceramic or other industries has not been determined.

Veins that occur in the pyroxenite mass contain—in addition to quartz—chalcopyrite, galena, sphalerite, fluorite, strontianite, celestite, aegirite, aegirite-diopside, and other minerals. Samples of the aegirites showed the presence, respectively, of nearly 4 per cent and nearly 3 per cent of vanadium oxide (V_2O_3). A sample of a part of one vein contained about 2 per cent of copper.

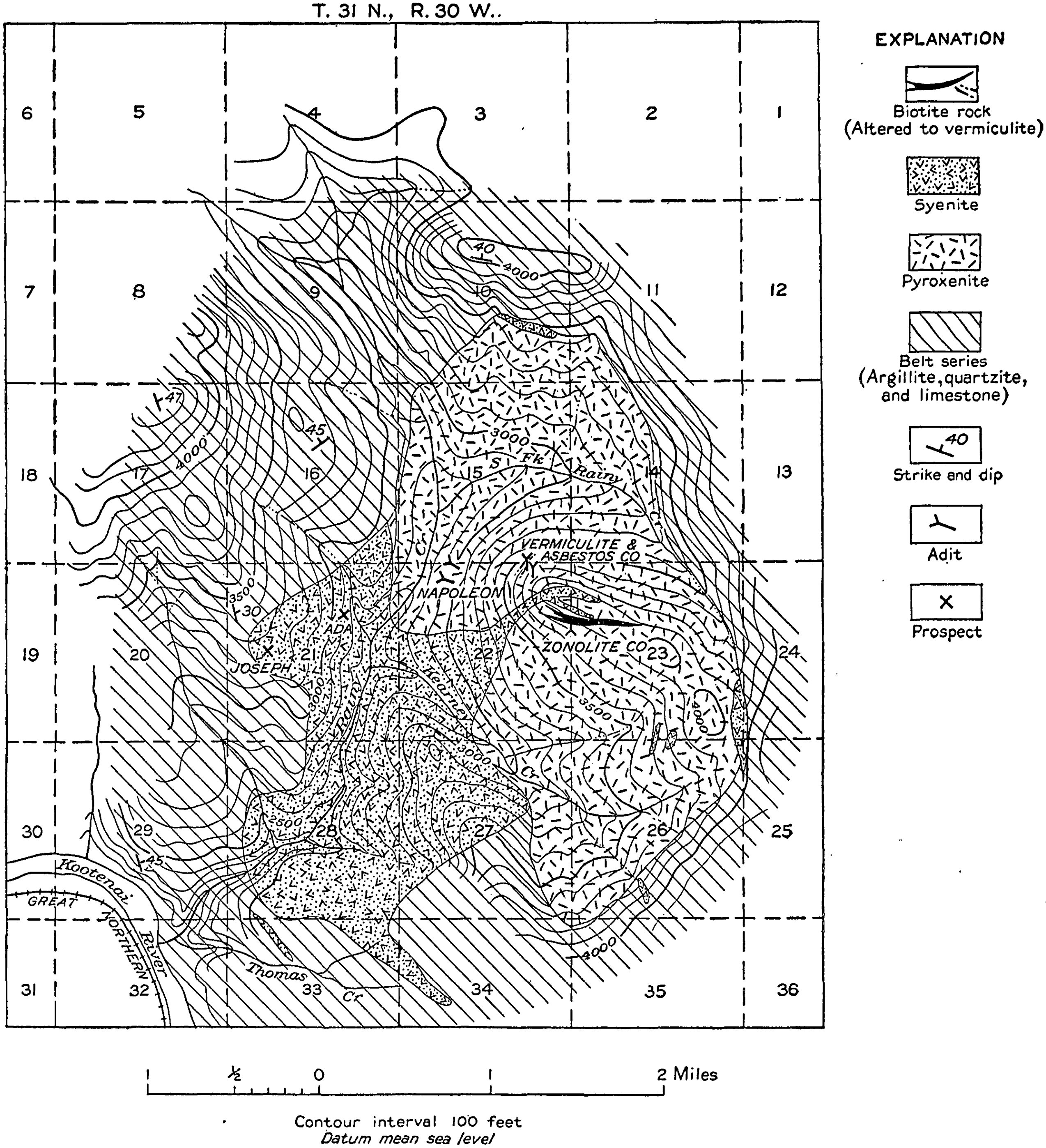
INTRODUCTION

The deposits described herein have been visited by the writers at different times between 1911 and 1927. During the earlier part of that period quartz lodes along Rainy Creek were being developed by B. M. Thomas, since deceased, whom the writers hold in grateful recollection for aid and courtesies extended to them in the field. The specimens collected at that time included several unusual and interesting kinds of rocks and minerals. Analyses of some of them in the laboratory of the United States Geological Survey showed, among other things, the presence of considerable vanadium, on which a report was published.[1] After the death of Mr. Thomas several years ago development work ceased for a time. During the World War the demand for steel-hardening metals directed the attention of E. N. Alley, of Libby, to the area as a possible source of vanadium. While searching a small tunnel for ores of that metal he observed that the flakes of a coarse micalike mineral in the walls swelled enormously when heated by the flame of his candle. The flaky mineral proved to be vermiculite, and further examination showed it to be present in great quantities. Since then Mr. Alley and others, incorporated as the Zonolite Co., have developed this unique deposit and built a plant at Libby to convert the crude vermiculite into the product which they call "zonolite." More recently several companies have been formed to exploit other deposits in the same area.

GEOGRAPHY

The area under consideration is the lower part of the basin of Rainy Creek, about 7 miles northeast of Libby, Mont. (See pl. 1.) It is easily reached from the main automobile highway along the north bank of the Kootenai River by a short branch road up Rainy Creek. The Great Northern Railway approaches within 2 miles, but it lies on the opposite bank of the river. A few miles below Rainy

[1] Larsen, E. S., and Hunt, W. F., Two vanadiferous aegirites from Libby, Mont.: Am. Jour. Sci., 4th ser., vol. 36, pp. 289–296, 1913.



GEOLOGIC MAP OF THE RAINY CREEK DISTRICT, T. 31 N., R. 30 W., MONTANA

Creek, however, a logging railroad crosses to the north bank. The name Rainy Creek is said to be a corruption of Rennie Creek, the stream having originally been named after a prospector, John Rennie, who explored its basin about 40 years ago.

For a mile above its mouth the valley of Rainy Creek is narrow and steep-sided. Farther up it is wider and its bordering slopes gentle. This upper stretch, together with several small branch valleys, forms a basinlike depression surrounded by mountains 1,000 feet or more high. Within it the local relief ranges from 500 to 1,000 feet. The altitude at the mouth of Rainy Creek is somewhat less than 2,100 feet, and the ridges surrounding the basin reach 4,500 feet or more.

GEOLOGY

BELT SERIES

The Rainy Creek basin is underlain chiefly by argillite and quartzite that apparently are the equivalents of the rocks exposed along the Kootenai River west of Libby described by Calkins [2] as follows:

Summary of section in gorge of Kootenai River between Troy and Libby, Mont.

	Feet
Argillite, greenish gray and dark blue, finely laminated, not continuously exposed	4, 300
Quartzite and indurated sandstone and shale, reddish purple and green	1, 250
Argillite grading into sericitic quartzite, mainly green, but with purple strata interbedded	1, 400
Argillite, siliceous, greenish gray, in part somewhat calcareous and weathering to a yellow color; dip flat, about	1, 000
Limestone, cream-colored, weathering somewhat yellow, with some partings of green argillite, exposed near Kootenai Falls	30
Shale, indurated, and shaly limestone and quartzite, purple and gray-green, with some calcareous bands	600
Argillite, mostly greenish gray, weathering yellow as if calcareous, sun-cracked and ripple-marked	3, 200
Argillite, purple	5
Argillite, gray-green	100
	11, 885

No detailed examination of these rocks was made in the Rainy Creek area, but in general they exhibit moderately steep dips and open folds that trend northwestward. Near the borders of the intrusive stock described farther on the argillite is altered to a faintly banded hornstone; elsewhere the rocks show the effects of regional metamorphism only. They doubtless belong to the Algonkian Belt series.

[2] Calkins, F. C., A geological reconnaissance in northern Idaho and northwestern Montana: U. S. Geol. Survey Bull. 384, p. 76, 1909.

PORPHYRY

Small dikes of a rather dark gray rock that is classified as quartz latite porphyry are apparently the oldest intrusive rocks present. They penetrate the Belt series in many places, but none were seen cutting the other igneous rocks. They consist of phenocrysts of white feldspar (plagioclase) in a fine-grained groundmass made up of quartz, feldspars (orthoclase, plagioclase), and alteration products, including epidote, sericite, chlorite, calcite, and biotite.

INTRUSIVE STOCK

A stock of alkaline rocks intrusive into the Belt series underlies an area of about 6 square miles in the basin of Rainy Creek. (See pl. 1.) It is composed of pyroxenite and syenite and their alteration products; the pyroxenite is the older of the two. These rocks, especially the pyroxenite, are much less resistant to weathering and erosion than the surrounding Belt rocks, and a basin has, therefore, developed in them.

Pyroxenite.—A coarse-grained pyroxenite composes about two-thirds of the stock. It is a soft dark-green rock that forms the gentler slopes and offers few natural outcrops. In most places the rock is so friable that it can be crushed to a sand by squeezing in the hand. In mining operations holes for blasting commonly can be made in this rock with an ordinary auger.

In mineral composition the rock ranges from nearly unmixed pyroxene to nearly unmixed biotite or its alteration product vermiculite. Apatite high in fluorine commonly makes up 7 to 10 per cent of the rock, which therefore is the richest in apatite among all the large bodies of rock known to the writers. Feldspar (microcline microperthite) occurs in amounts as much as 15 per cent of the mass. The accessory minerals are chiefly magnetite (or ilmenite) with rarely titanite and garnet.

As shown by the analysis of a representative sample taken from a tunnel on the Napoleon claim, the pyroxenite is composed chiefly of the silicates of iron, calcium, and magnesium. The rock contains proportionately less silica and magnesia and more iron and lime than most pyroxenites. It is high in phosphorus and fluorine; these elements together with much of the excess of lime are contained in the apatite previously mentioned. An unusually interesting feature is the presence of a noteworthy amount of vanadium.[3] The complete analysis follows:

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[3] Larsen, E. S., and Hunt, W. F., op cit., p. 293.

Analysis of pyroxenite from Rainy Creek, Mont.

[Analyzed by George Steiger in the laboratory of the U. S. Geological Survey. Nickel not tested for. Specific gravity, 3.417, measured on a full-sized hand specimen]

	Per cent		Per cent
SiO_2	37.47	CO_2	0.36
Al_2O_3	2.86	P_2O_5	4.33
Fe_2O_3	11.77	S	.04
FeO	7.83	F	.36
MgO	10.12	V_2O_3	.12
CaO	21.68	MnO	.16
Na_2O	.47	BaO	.06
K_2O	.93	SrO	.14
H_2O-	.27		100.77
H_2O+	.73	Less O	.02
TiO_2	1.07		
ZrO_2	None.		100.75

Syenite.—About one-third of the Rainy Creek stock consists of syenite, the main body of which occupies an area of about 2 square miles in the southwestern part. In addition many small bodies of syenite cut the pyroxenite, only the larger of which are indicated on the map. Much of the syenite is variable in texture, and the mass is probably made up of several separate but related intrusive bodies.

The rock of the main body is medium to coarse grained, nearly white where fresh but iron stained on weathered surfaces. It is composed chiefly of intergrown potash and soda feldspars (microline microperthite), with about 15 per cent of secondary muscovite in coarse plates. Accessory and secondary minerals, which as a rule are present in small amounts, include dark hornblende, fluorite, apatite, titanite, rutile, biotite, and garnet.

The dikelike body that projects into the ridge north of Kearney Creek is a medium-grained greenish-gray to nearly white rock with numerous streaks and bunches of a darker color. It is also made up chiefly of microperthite. The darker parts are rich in pyroxene and titanite. A dike of syenite at the northern extremity of the stock is opened for nearly 100 feet by a tunnel. This rock is giant grained and composed mostly of intergrown potash and soda feldspars (perthite) cut by very numerous veinlets of green pyroxene (diopsidic aegirite).

South of the stock in the Belt rocks, on the ridge north of Thomas Creek, is a small dike of nepheline syenite. This rock varies irregularly from fine to coarse grained, and the coarser grains have diameters as great as 7 inches. It is composed chiefly of the soda feldspar albite, the closely related mineral nepheline, and the potash feldspar microcline in nearly equal amounts. In addition there are small amounts of aegirite, apatite, and magnetite and secondary fluorite and zeolites. In the hand specimen the rock is seen to consist mainly of white feldspar. The nepheline occurs in crystals several inches across, which on account of their brown tint and greasy luster show plainly in contrast with the porcelain-like feldspar.

GRANITE AND MONZONITE

A few small dikes of nearly white granite cut the Belt rocks, and one such dike a few inches wide was observed to penetrate the syenite. The rock is composed mainly of feldspar and quartz with small amounts of pyroxene, apatite, titanite, fluorite, and magnetite. On the Ada claim a small dike that cuts the pyroxenite shows small porphyritic crystals of feldspar and green hornblende in a fine groundmass. It is to be classified as quartz monzonite porphyry.

HYDROTHERMAL METAMORPHISM

Changes in the stock by the action of hot solutions have been so widespread and so unusual in character as to deserve special notice. The principal minerals produced by these changes are white mica, aegirite, aegirite-diopside (both locally vanadiferous), vermiculite, and fibrous amphiboles. Locally titanite and feldspars are developed, and also quartz veins containing chalcopyrite, pyrite, galena, sphalerite, strontianite, and other minerals. In the following pages the present or prospective economic value of several of the minerals is discussed.

MINERAL DEPOSITS

VERMICULITE

Character.—The vermiculites are micalike minerals that give off much water when heated and therefore exhibit the physical character of exfoliation. Some kinds are described as slowly opening out into long wormlike threads, hence the group name. Dana[4] lists more than a dozen varieties of vermiculite from different places. The variety from West Chester, Pa., called jefferisite resembles the vermiculite from Rainy Creek more closely perhaps than any of the others. Dana describes it as occurring

> in broad crystals or crystalline plates. Surface of plates often triangularly marked by the crossing of lines at angles of 60° and 120°. Cleavage: Basal, eminent. Flexible, almost brittle. H.=1.5. G.=2.30. Luster pearly on cleavage surface. Color dark yellowish brown and brownish yellow; light yellow by transmitted light; also greenish yellow.

General occurrence.—Vermiculite is a constituent of some altered igneous rocks, and it generally occurs mixed with other minerals and

[4] Dana, J. D., The system of mineralogy, Descriptive mineralogy, 6th ed., pp. 664–668, New York, John Wiley & Sons, 1909.

thus distributed through the rock mass. In a few places, however, it is found in almost clean or unmixed bodies large enough to mine. Bodies that have a dikelike form and range from 1 to 6 feet in width are reported from North Carolina. So far as known no commercial use has been made of them. A deposit in Chaffee County, Colo., is described by Sterrett[5] as follows:

A hydrated form of biotite mica found about 5 miles southeastward of Hecla, in the Turret mining district, has been used in the industries during the last few years. The material is mined and handled under the name of tung ash by the Denver Mining & Manufacturing Co. By calcining the mica as it comes from the mines and then crushing and sizing, a ground product with a rich golden-bronze to silver color and metallic luster is obtained. This is suitable for various decorative purposes. Because of the expansion and exfoliation the mica undergoes when calcined a little of the crude product will make a large quantity of the calcined product. The finished tung ash is light, and a small quantity will spread over a large surface.

According to Mr. W. W. Kirby, secretary of the company, the mica is found in veins that lie between gray granite and hard black schist and that reach in places a thickness of 4 feet. It occurs in shoots about 40 feet long, very much like ores in metalliferous veins, and forms solid masses of crystals, the largest 2 or 3 inches in diameter, bunched together at different angles. In the parts between the ore shoots a similar variety of mica forms about 50 per cent of the filling. The mica is greenish to brownish black. The folia are flexible and inelastic. When heated they swell and exfoliate vary much like vermiculite. The laminae of the calcined product are sufficiently separated and brittle to break down into a fine scaly product, which exhibits the colors and luster already mentioned.

Deposits of vermiculite in the Turret district, 14 miles north of Salida, 9 miles from Iola, Gunnison County, and at Westcliffe, Custer County, Colo., are described briefly by Alderson.[6] The largest of these deposits, the one at Westcliffe, has a maximum width of more than 13 feet and is more than 30 feet long.

Occurrence in the Rainy Creek district.—A body of vermiculite in the Rainy Creek district that is being developed by the Zonolite Co. on the spur north of Kearney Creek is much larger than any deposit heretofore known. It presents no natural exposures, but its outcrop and the slopes below are mantled with a yielding slippery soil composed chiefly of micalike flakes. As incompletely shown by the workings so far made, this body appears to be of dikelike form and at least 100 feet wide and 1,000 feet long. It extends to a depth of more than 100 feet, its lower limit not being shown. Several smaller bodies of vermiculite occur in the ground of the Vermiculite & Asbestos Co. on the northwest slope of the same spur. There a

[5] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, p. 50, 1923.

[6] Alderson, V. C., Jefferisite, Colorado School of Mines, no date.

tunnel penetrates six bodies that range from 1 to 4 feet in width. They are of flat lenslike or tabular form, and most of them are definitely separated from the wall rock by fault or slip planes. Incomplete exposures of several other similar bodies are made by smaller workings.

The vermiculite is an alteration product of biotite and locally is one of the main constituents of the pyroxenite mass. In open cuts and tunnels that are scattered over the upper part of the spur north of Kearney Creek it appears generally to make up 30 per cent or more of the rock. Samples representing areas of several square feet at different places in the workings of the Vermiculite & Asbestos Co. contained from 30 to 84 per cent of vermiculite. Apparently there is a huge amount of such mixed material.

No analyses showing the chemical composition of the vermiculite from Rainy Creek are available. Specimens from different places described by Dana[7] are all hydrated silicates of magnesium and aluminum containing more or less iron.

Production and uses.—As an economic product vermiculite is comparatively new. An unknown but probably small amount has been mined in Colorado. In the Rainy Creek area near Libby, Mont., the Zonolite Co. reports 1,500,000 pounds mined and converted into the heat-expanded product zonolite and 100 tons sold in the crude form. Prices range from $10 or less a ton for the crude vermiculite to $20 or more a ton for zonolite. The most striking features of the vermiculite from Rainy Creek are its properties of expanding enormously when heated and at the same time assuming golden or silvery lusters. The expanded material floats on water and is nearly as light as cork. It appears to have a very low heat conductivity and to be capable of resisting high temperature. These qualities at once suggest it to be useful for heat and cold insulation and similar purposes. Uses reported by the Zonolite Co. include fireproof roofing, plaster, and wall board, packing for safes and refrigerators, acoustic and sound-deadening plasters, pipe and boiler covering, electrical insulation, and wall-paper decoration.

FIBROUS AMPHIBOLES

Locally the pyroxene (diopside) of the large pyroxenite mass has been changed by hydrothermal metamorphism to an amphibole of fibrous habit, related to tremolite. The minerals known commercially as amphibole asbestos are more or less useful, their value depending on their quality and the relative location of the deposits. Amphibole asbestos is found in many places in the Appalachian and

[7] Dana, J. D., op. cit., p. 665.

western mountain regions. Usually it is associated with igneous rocks and occurs as veins and bodies of dikelike form. The principal bodies that have been worked are in Georgia. In recent years small amounts have been mined in North Carolina, Virginia, and Maryland. Little is known of the deposits in the Western States, except one near Kamiah, Idaho, which is described by Diller[8] as including half a dozen ledges within a few square miles. The largest of these ledges is lenticular in form, about 200 feet long and 40 feet wide.

In the Rainy Creek district in Montana the workings of the Vermiculite & Asbestos Co. expose several bodies of amphibole asbestos which are of dikelike or tabular form and of different widths. The largest, as exposed by open cuts, appears to be 100 feet or more long and from a few feet to 14 feet wide. A body 4 feet or more wide exposed in the face of a tunnel at a depth of 150 feet may be the downward continuation of the same deposit. Several smaller bodies are exposed in other workings. Samples representing the different bodies show the amphibole to be mixed with 1 to 10 per cent of other minerals, chiefly vermiculite and unaltered pyroxene. In other places the country rock is particularly rich in amphibole. A sample across a width of 16 feet of the rock as exposed by a short tunnel contains, in round figures, 75 per cent of amphibole, 15 per cent of pyroxenite and apatite, and 10 per cent of vermiculite. A sample representing another body 50 feet wide consists of 50 per cent of amphibole, 30 per cent of pyroxenite, and 20 per cent of vermiculite.

In several places elsewhere on the spur north of Kearney Creek the pyroxenite appears to be comparably rich in fibrous amphibole. Doubtless, if necessity arose, the fibrous mineral could be separated from the other rock constitutents, and in that event the richer parts of the pyroxenite mass might be the source of a very large amount of the fibrous mineral.

As commonly understood, the term asbestos embraces the fibrous varieties of several minerals, including anthophyllite, tremolite, actinolite, and crocidolite, which belong to the amphibole group, and chrysotile, a variety of serpentine. The usefulness of these minerals depends on their resistance to heat and the strength and flexibility of their fibers. All the varieties mentioned except crocidolite are about equally resistant to heat.

The tremolite and anthophyllite asbestos are more resistant to acids than chrysotile and crocidolite, but in flexibility and strength of fiber chrysotile and crocidolite are far superior to the others. The

[8] Diller, J. S., U. S. Geol. Survey Bull. 470, pp. 519, 520, 1911.

asbestiform minerals are classified also as cross fiber and slip fiber, according to whether the fibers are crosswise or parallel to the walls of the body. Mass fiber is the name applied to material in which the fibers or groups of fibers stand at various angles. Most of the chrysotile and the better or more valuable grades of amphibole asbestos occur as cross fiber in narrow veins that compose but a small part of the rock removed in mining. The cheapest grades of asbestos are mass-fiber amphibole, which, however, is commonly found in bodies of fairly large size.

The annual production of amphibole asbestos in the United States from 1915 to 1925, as reported in the volumes of Mineral Resources, has ranged from 42 to 1,415 tons. The average price during the same period ranged from $8 to $160 a ton. In 1922, when the last-mentioned price was attained, the amount produced was only 42 tons, most if not all of which was a high-grade cross fiber from Pylesville, Md. The years of low price were years in which the production increased and was made up chiefly of mass-fiber anthophyllite. As some of the more valuable cross fiber is included in the total amounts reported, the price of mass fiber in 1925, for example, must have been somewhat less than $9 a ton.

The bulk of the amphibole asbestos produced in recent years in the United States has come from Georgia. Small amounts have been reported from Maryland, Virginia, North Carolina, California, and Washington. The deposit near Kamiah, Idaho, previously mentioned, has been operated intermittently since 1916, small shipments being made in 1917 and 1925. Most of the product reported has been used as a constituent in millboards, roofing, flooring, plasters, cements, paint filler, pipe coverings, and similar articles. A small part has been used for making chemical filters, for which, as already explained, the amphibole varieties, because of their resistance to acids, are particularly well suited. However, material for this purpose must be exceptionally clean and free from impurities of any sort, and in general its value for any purpose varies according to the strength and separability of its fibers. A small amount of amphibole asbestos has been mined in the Rainy Creek district for experimental purposes, but no commercial production is reported.

The asbestos from Rainy Creek is related to tremolite, but the presence in it of considerable soda and ferric iron suggests that it will be less resistant to heat than the true variety of tremolite. Near the surface the asbestos is rather soft and easily separated or fiberized. The fibers are weak and inelastic and break into short pieces, but they compose a fluffy mass that to all appearances is similar to the general run of amphibole mass fiber. Samples from places not affected by weathering consist of rather harsh fibers that are not so easily separated as those in the weathered material. To obtain a usuable product more or less impurities would need to be separated from all the bodies that were seen. The value of the Rainy Creek deposits apparently depends on the development of near-by markets.

FELDSPAR

Most of the large mass of syenite in the Rainy Creek district is of fairly uniform composition. It is made up chiefly of alkaline (potash-soda) feldspars with about 15 per cent of white mica (muscovite) in aggregates of coarse plates. Ferromagnesian minerals are almost entirely absent, but some magnesia is present in the mica, and a little iron is indicated by the characteristic stain.

In the United States considerable alkaline feldspar is used in making pottery, chinaware, porcelain, and other ceramic products. Most of the quarries are near the eastern seaboard, where feldspar deposits are locally abundant and where the ceramic industries are concentrated. A few are in California. The value of any deposit depends on its accessibility, nearness to markets, size, and quality. The body at Rainy Creek is of large size, but whether its quality will meet economic requirements has not been determined. It is easily accessible, but it is rather distant from established markets.

COPPER, LEAD, ZINC, AND VANADIUM

Veins that are found chiefly in the pyroxenite area were partly explored several years ago, as mentioned on page 18, in a search for metalliferous minerals. One of the veins, which is developed by some short tunnels and shafts on the Napoleon and Copper Antler claims, is about 10 feet wide. The middle part is chiefly quartz with scattered grains of galena and chalcopyrite. Next to the walls are zones a few inches wide made up chiefly of vanadium-bearing aegirite, microcline, strontianite, celestite, pyrite, and chalcopyrite with smaller amounts of quartz, fluorite, galena, and sphalerite. A representative sample of one of the zones, analyzed by R. C. Wells in the laboratory of the United States Geological Survey, contained 1.92 per cent of copper.

The vanadiferous aegirite is the most conspicuous mineral of the zones. It occurs as black needles as much as half an inch long that project from the walls and also form radiating nodules or spherulites embedded in the other minerals. An aegirite-augite (diopside) occurs also in veinlets in the form of nodules an inch or less in diameter composed of fine radiating fibers. The composition of these two pyroxenes is as follows:

Analyses of vanadiferous aegirite and aegirite-augite from the Rainy Creek district, Montana

[Analyzed by W. F. Hunt in the laboratory of the U. S. Geological Survey]

	Aegirite	Aegirite-augite		Aegirite	Aegirite-augite
SiO_2	51.91	53.32	Na_2O	10.46	6.26
TiO_2	.91	.38	K_2O	.22	.26
Fe_2O_3	21.79	12.38	Cr_2O_3	----------	Trace.
V_2O_3	[a] 3.98	[b] 2.86	H_2O-	.06	.07
Al_2O_3	.38	1.40	H_2O+	None.	.13
CaO	5.53	12.18	S	.13	----------
MgO	3.08	7.01	CO_2	Trace.	----------
FeO	1.48	3.70			
MnO	.58	.45		100.51	100.40

[a] A duplicate sample gave 3.81 per cent. [b] A duplicate sample gave 2.82 per cent.

For a few inches on both sides of the veins the pyroxene of the wall rock is changed to a fibrous amphibole related to actinolite and glaucophane. Some calcite, pyrite, and chalcopyrite are present in the altered rock, and locally there are sulphides and large amounts of quartz. On the Joseph claim a small vein that cuts the syenite consists of quartz and a little chalcopyrite and its oxidation products. The nepheline syenite dike south of the main syenite body is also cut by a quartz vein that shows a little pyrite and galena. Several small quartz lodes occur in the belt of slightly metamorphosed sedimentary rocks surrounding the intrusive stock. One of these lodes near the nepheline syenite dike on the divide north of Thomas Creek consists chiefly of quartz and fluorite that are stained green with copper carbonates. Others farther northwest, near Rainy Creek, show copper-stained quartz. A few that were observed west and north of the intrusive mass showed quartz only.

Although they are of unusual interest for their mineralogy, the veins are probably not rich enough in materials of economic value to be worked under present conditions.

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